

Quantitative Approaches to Lunar Economic Modeling

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Abstract

Decision analysis tools have long been used in the extractive industries to discern the expected value of short and long-term investment in mineral properties and infrastructure. These tools may also have utility in quantifying costs and benefits related to future investments in human space exploration and technology, and more specifically to aid in down selection when a number of viable alternatives exist. This paper will describe various quantitative lunar economic modeling efforts conducted at the Colorado School of Mines (CSM) during 2002-2005 time frame.

A series of In-Situ Resource Utilization (ISRU)-based human exploration architectures were developed at the CSM Center for Commercial Applications of Combustion in Space (now the CSM Center for Space Resources). Architectural development, production and operations costs were modeled using the NASA and Air Force Cost Model (NAFCOM). Revenues related to ISRU product sales to various modeled future markets for in-space propellant and commodities formed the foundation for an economic cost/benefit model of the value of the use of space resources. The modeling approach included infrastructure and capability growth as a function of time. These architectures are generally consistent with the development of a self-sufficient outpost on the Moon during the period 2020-2030, and rely on systems and technological assumptions similar to the current NASA lunar architecture. Critical assumptions include deploying a set of precursor robotic missions were assumed to emplace ISRU capabilities as well as infrastructure in preparation for human missions. Model results included economic and performance (mass ratio) benefits and relative costs of ISRU compared to baseline expendable lunar scenarios. Sensitivity analysis of various technology options enabled the identification of priorities for future research and modeling. Economic conclusions included expected product unit costs and rate of return analysis as a function of resource concentration, market size as well as capital and operations costs.